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## ON THE ANALYSIS OF THE MEMORY CONSCIOUSNESS FOR PICTURES OF FAMILIAR OBJECTS.<sup>1</sup>

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### A. INTRODUCTORY.

I. *The Problem and Aim of the Study.* The present study is a continuation of a program begun in one previously re-

<sup>1</sup>In this study acknowledgments are due to Prof. Joseph Jastrow, and to Prof. E. C. Sanford for their kindly interest and the generous opportunities offered to carry out the work; to Dr. W. F. Dearborn, and Mr. E. A. Jenner, University of Wisconsin, and to Dr. H. S. Britton, and Mr. George Ordahl, Fellows in Clark University, for their patient and expert work as subjects.

ported.<sup>1</sup> A few studies made by other investigators on the analysis of the memory consciousness were there briefly noted. In another place an attempt was made to outline what seemed to me the central problems in the general field of memory analysis.<sup>2</sup> For the present purpose it will be sufficient to recall a few of the more general questions in memory analysis with which the present study is chiefly concerned. Relatively speaking, nearly all previous memory studies have dealt with the quantitative aspect of memory, and a much smaller number with the determination of the types of mental imagery. The analysis of the memory consciousness is not at all concerned directly with the former of these problems, and the latter is only a very small part of its general aim. This general aim is threefold. First, the analysis of the memory consciousness into its elements. What different kinds of mental imagery, what organic sensations, and affective states occur in the mind from the beginning to the end of the process of the recall of a given thing? Secondly, the determination of the function in the memory consciousness of each of these elements. What is the order in which they appear, of what use is each in attaining the end that is desired, to wit, the reinstatement of the imagery that is wanted and the recognition of this imagery as correct or not? Thirdly, since the end product of a recall process is often a memory illusion, a prominent question in memory analysis is that of the nature and causes of these memory illusions. In the actual investigation of memory these are not independent general problems; for any study that is aimed mainly at any one of them will yield, and needs, considerable data with regard to the others, the second necessarily presupposing results on the first.

The results of studies of mental imagery hardly answer any part of these general questions directly. In our usual thinking we are not given free choice as to what sort of imagery we shall use in recalling things, because the occasion so often demands that we recall how a thing looks, or sounds, or tastes, etc. Thus, for example, to know that when one is given that choice one's imagery will be visual in 50% of the cases, auditory in 30%, motor and tactual in 15%, will not tell us much about the nature of the memory content in the total process of the recall of any one given aspect of a thing. Furthermore, the mental imagery studies do not tell us anything about the function of the different elements (different kinds of imagery),

<sup>1</sup> On the Analysis of the Memory Consciousness: A Study in the Mental Imagery and Memory of Meaningless Visual Forms. Psy. Rev., 1906.

<sup>2</sup> Problems in the Analysis of the Memory Consciousness. Jour. Philos., Psy., and Sci. Meth., 1906.

that enter such a process of recall. If I am trying to recall the nature of sounds I have heard I must recall auditory imagery, but it is not likely that my recall process will be made up entirely of a succession of auditory images. It will include most likely visual imagery of the things that produced the sounds, verbal imagery of their names or verbal description of some of their characteristics. It might include tactful, gustatory, and other imagery in addition. This secondary, non-auditory imagery which does enter may serve some purpose in the total memory consciousness, or it may not. In this given case of the memory consciousness for sounds, therefore, our double question of analysis into elements and determination of function would consist of determining what secondary imagery does enter, and what part it plays in the reinstatement of the auditory imagery and in the recognition of its correctness.

There are certain conditions which we know beforehand will determine in part both the kind of secondary imagery that will enter a recall process and its function. The first of these is the sense department in which the perceptive experience is given. A second is the degree of complexity and the familiarity of the material to be recalled. A third is the time interval since the original perceptive experience and the frequency of intermediate recalls. A good many others might be added, but these are the main ones. In the previous study referred to above meaningless visual forms were used, a group of which the subject committed to memory and recalled several times with detailed introspection and with increasing time intervals between the successive recalls. In the present study pictures of familiar objects were chosen because they present, as regards associated meaning and familiarity, a wide contrast to meaningless forms. The two classes of material together cover fairly well the range of differences in this respect.

In the present study, as in the previous one, the question of the function of the secondary and other associated imagery that entered the recall process was kept in the foreground, but the pictures of familiar objects offered the possibility of more and greater variety of imagery than was the case with the meaningless forms. The objects represented in the pictures, as may be seen in the cuts given below, were such as might appeal to all the special senses. Thus in the recall of some there was given the possibility, at least, of verbal, auditory, tactful, motor, gustatory, and olfactory imagery of the things represented; and this might appear in the recall process either before or after the visual image had been reinstated. But it may be stated at once that as a matter of fact auditory imagery entered only a few times, and then only in the case of one subject, and tactful, gustatory, and olfactory imagery

never entered at all. This, then, is so far a characteristic of the recall of the visual aspect of things. In the analysis of the recall process as such we shall be concerned alone with the detailed description of the nature and function of other associated visual, verbal, and motor imagery, and shall consider how these were influenced by the lapse of time and the repetition of recall. To this will be devoted section C of the outline: "The Subjects' Methods of Recalling a Picture as a Whole." After the recall of the visual image of the picture as a whole has been considered, we shall proceed to the description of the recall of its further details. Here I shall take up especially what I have called the "criteria of correctness," which, as will be seen, was an essential factor in the process of recall, as well as in the cognitive consciousness, using this last term in a wide sense. The complete visual imagery of a picture as finally recalled was often wrong. These inaccuracies will be taken up in the section on "Changes in the content of the imagery," and their causes discussed.

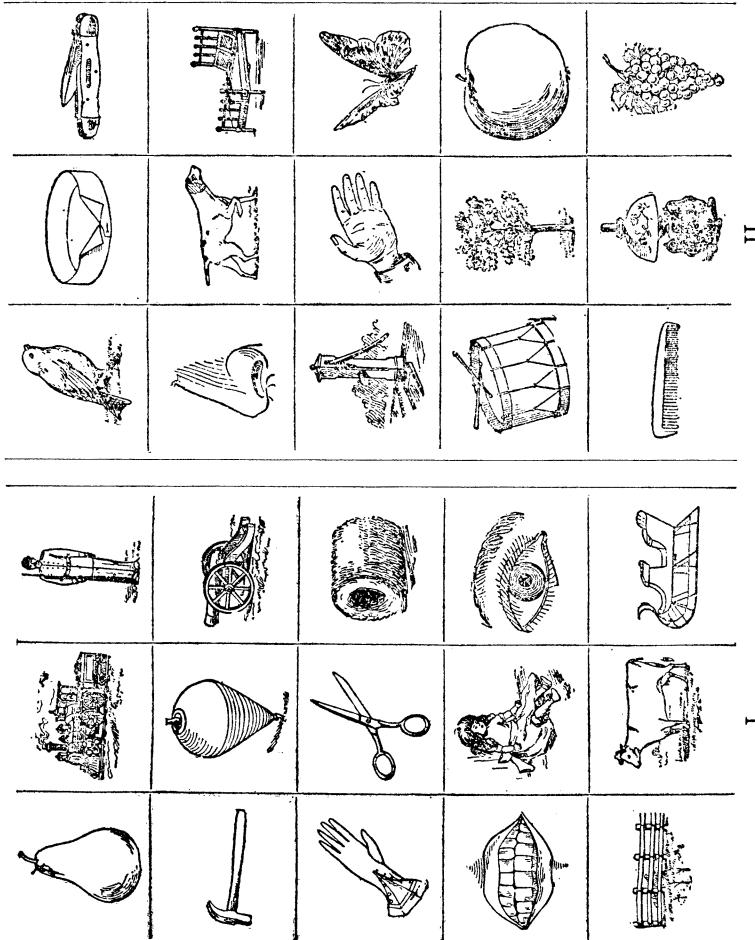
2. *Method of Study and Procedure.* Two groups of pictures were used, and five subjects participated in the experiment.<sup>1</sup> The cuts show, on a slightly reduced scale, the character and the arrangement of the pictures in the groups. They were in black and white and the square spaces for the individual pictures were square inches.

In making the experiment a group was placed before one of the subjects at reading distance and he was given from six to twelve minutes in which to commit it to memory. He was told beforehand what the later procedure in the experiment would be, and that he should attend to the details in the pictures as much as possible in the time allowed. During the six to twelve minutes he was told when half his time had passed, and again when only one minute was left. The subject did not, after this, see the pictures again at any time. Immediately after memorizing a group the first introspective recall was required. The method of study and analysis was entirely that of introspective observation. In this immediate introspective recall the subject was first asked to describe in detail how he went about memorizing the group, and then to recall the individual pictures, one at a time, giving the order and nature of the imagery for each, the presence, character and use of associations, etc. This process, except the questions on how the pictures were memorized, was repeated three times after this with increasing time intervals, several days inter-

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<sup>1</sup> As in the former study, the writer was the subject in a few weeks of preliminaries to determine minor matters of procedure, and was also one of the subjects in the regular experiment later.

vening between the immediate and the second recall, about ten days between the second and third, and about four weeks between the third and fourth.<sup>1</sup> In all but the immediate recall the procedure was divided into the two following parts: The



subject was first asked to recall the group as a whole, naming the pictures, but not stopping to recall any details, letting the

<sup>1</sup> These intervals varied somewhat, as a rigid adherence to uniformity would have involved great inconvenience to the subjects. But nothing in the experiment required greater uniformity than was secured.

recall take its own, passive course. When introspection on this was completed, which required giving the order and nature of the imagery, and the use made of it, for each picture, he was asked, secondly, to recall each picture in as much detail and as well as possible and to give his observations as before. In this part one picture was taken at a time.

The whole procedure was carried through with the two groups of pictures and five subjects, excepting that two of the subjects had only one group of pictures each, and for the last two subjects the upper three pictures in the first group, and the lower three in the second group were removed, and the time for memorizing them was shortened.<sup>1</sup> The aim was to allow for the memorizing just sufficient time to insure ready recall of all the picture at the first sitting. Usually then some would be entirely forgotten by the second or third sitting.

#### B. SUBJECTS' METHODS OF LEARNING THE MATERIAL.

How one will recall what he has memorized depends necessarily in the first place on how he has gone about committing the things to memory. The kinds of associations and secondary imagery he will use in recall will depend on the kinds made use of in learning the material. An analysis of the latter will therefore always throw some light on what occurs in the recall process. One's method of memorizing any given material will depend again on a number of conditions, the more prominent among them being the nature of the material, and the manner in which it is presented. Generalizations on this point cannot be made *a priori*, but a few general suggestions from analyses already made will help to give more meaning to the following description of what occurred in the subject's mind while memorizing the group of pictures, in other words, to his methods of learning the material.

If material for memorizing is presented to one sense, the subject has always the choice of using or of not using mental imagery from other senses, motor processes, and verbal descriptions in committing that material to memory. If we call these latter *aids* in memorizing, he may, further, give more attention to the aids than directly to the sense field in which the material is presented. If the material is visual, he may, for example, give more attention to learning the names and to verbal description, or some other aid, than to the visual aspect of the things presented and to visual imagery. From studies previously made it can be said safely that the subject will use

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<sup>1</sup> The number in a group was determined simply by the time required for the introspective recall. A group of fifteen made a sitting of an hour and a half, which was found too fatiguing.

quite different aids, and use them in different ways, according as the material is visual, auditory, olfactory, etc. Similar statements can be made in regard to the dependence of the methods of learning on the complexity and familiarity of the material, in whatever sense department it is presented. Also, the way of presenting the material will determine in part the procedure of the subject. If the different things in a group or list are presented simultaneously, he will do differently from what he will do when they are presented successively. Simultaneous presentation favors the use of associations among the objects presented, and will also make the subject voluntarily divide his time between perception of material and trial recall. A good many other matters of this sort might be mentioned. But this is not necessary, if it is clear that an exact analysis of all that the subject does while memorizing the material, when all the conditions are taken into account, should be made and kept in mind in order to help the understanding of many things about the recall process. Some matters about the methods of learning are quite naturally so general as to be independent of the particular subject and of many of the alterable conditions of the experiment. Others are entirely dependent on some minor point in the procedure. The following analysis of the subjects' methods of learning the material includes all the details that were definitely established in the present series of experiments.

Without an exception, the subjects learned the pictures in order from left to right in the horizontal rows, and the rows from the top downwards. The regular arrangement of the pictures eliminated almost entirely any effort to commit to memory the positions of the individual pictures in the group. This took care of itself. It contributed further to the ease of memorizing by readily permitting associative grouping, and by fixing at once a definite order of procedure. Also without any exception, the subjects alternated learning with trial recalls several times during the six to twelve minutes allowed for memorizing. To determine in this way what could already be recalled and what needed further special attention usually took nearly half of the total time. While looking at the pictures the attention was always predominantly directed towards the visual, visually noting what the pictures were. Simultaneously naming them, and to a much less extent, describing details, might then incipiently accompany the visual process, or the subject might voluntarily attempt to keep in mind the names as he proceeded. In either case, the attention went first to the names in the trial recalls. With only one exception (one subject for one group of pictures) the effort in the trial recalls was to get first of all a series of names. Whether or

not he would visualize the pictures at all when going over this series depended on the subject. The reason for this attempt to get a series of names was variously given. It was for the sake of preventing forgetting any of them altogether, or because it was easier to recall the names than to visualize the pictures successively, or for the sake of fixing the order of the pictures. The first seems to have been the main one. The ability to recall all of them in some form was first sought for. Only after this could be done would attention be paid to the details of the individual pictures.

Noting visually what the pictures are and their details is properly regarded as the direct method of making certain the recall of their visual images. The aids to this direct process were then, first, the names that were always associated with the pictures. Verbal description of the details, which was a quite common aid with the meaningless forms, occurred so rarely with the familiar pictures that it may be left out of consideration. Secondly, associations between picture and picture (depending more on the subject than on the nature of the pictures) were frequently aids in memorizing the latter so that none would be forgotten as wholes. Associations were much less sought for than was the case with the meaningless forms; were much more easily obtained, coming in usually of themselves and in unexpected ways; and were of a larger variety, most of them being of a different nature from those used in the memory of meaningless forms. Taking a distinctly psychological, rather than a logical point of view, they fall into a number of classes: (1) A mere felt connection between two or more pictures. The subject would not be able to report in what way they were connected, or anything further about the nature of the association beyond the statement of the presence of this emotional reaction aroused by regarding the pictures in question. (2) Putting several together into one class, describing them by one adjective or phrase. Accompanying this classifying was an emotional reaction of the same general nature as above. In just a few cases there was introduced in addition an extra visual image that in some way represented the class. For example, *glove*, *scissors*, and *muff* were associated with 'millinery,' and a millinery store was visualized. *Teeth*, *child*, and *eye* were associated with 'things pertaining to human beings,' and a person visualized. (3) Putting several together as parts of one complex scene. In this a visual image of a complex scene was used in which the things represented by the several pictures associated were present as parts. Thus, *fence*, and *cow* were associated by a visual image of a cow in a pen, of a cow fenced in. *Pump*, *hand*, and *butterfly* were associated by the visual image of the subject pumping at a hand-

pump with a butterfly sitting on the ground nearby. In this class a verbal descriptive phrase might, or might not, accompany the visual scene. (4) Combining the names of the pictures into a phrase or a sentence. *Nose, dog, and bed* were combined into "The dog knows his bed." *Teeth, child, and eye* were combined into "Idol's teeth," regarding the child as a doll for this purpose. (5) With any individual picture various associative suggestions might occur without in any way connecting that picture with another. Excluding the names of things in the pictures, such associations with individual pictures were much more loosely connected with the images of the pictures than were the others. They, as a rule, did not seem to be an integral part of the total complex involved in the recall of the visual image of a picture and were regarded by the subject as "mere suggestions."

### C. SUBJECTS' METHODS OF RECALLING A PICTURE AS A WHOLE.

In this section will be considered the nature of the mental content in the process of recall, and its function in that process, when an attempt is made merely to recall the pictures as wholes, not stopping to recall any details of the visual imagery of the pictures. A consideration of the changes dependent on the lapse of time and the repetition of recall will also be included. We shall be concerned entirely with the aids to recall, for the kinds of aids that the subject uses and the way in which he uses them constitute his method of recall for the given conditions. In case of the immediate recall, the recall process was in a very general way a repetition of what occurred in the mind of the subject while looking at the group of pictures and during the trial recalls while memorizing them; the same kinds of imagery, the same aids, reappeared in the immediate recall in about the same way. But even in this immediate recall there were some significant changes both by way of omissions and of additions, while in the later recalls the whole process was often quite different in content, and in the function of the elements in that content, from the original learning process. The analysis of that part of the recall process that will concern us in this section will have to do with the following: (1) Some factors determining the order of recall; (2) the associations; (3) verbal imagery; (4) certain visual antecedents, that were not visual imagery of the picture itself. The term 'associations' is used here in a restricted sense. Only the mental content that was classed under "associations" above, and which was divided into five different kinds of associations, will be considered under this heading. The nature of the results makes this method more convenient than the

strictly logical one which would place nearly all the means of recall under the heading of associations.

1. *Some Factors Determining the Order of Recall.* As already stated, at each sitting, excepting the first one for a group, the subject was asked first of all to recall all the pictures while remaining in a semi-passive mood, letting the recall take its own course. He was requested to use a special effort only in inhibiting the recall of details of any one picture, if such a tendency should appear. The object of this was to determine the general mechanism of recall, as it would appear in the differences in the spontaneity of the imagery for different pictures, in the different classes of imagery for any picture, and in the presence and use made of associations. With this procedure, the order in which the pictures were recalled becomes significant. It shows some of the factors that are at work, and something about their relative efficiency in producing again the visual images of the pictures.

The general fact in regard to the order of recall was that at the first sitting the pictures were always recalled in the definite order in which they had been learned, from left to right and from the top downwards. At the second recall this order was already considerably broken up. At the third and fourth recalls it was changed still more, so that in individual cases little or nothing of the original order could be detected. Arranged in a table of distribution, all the cases taken together show only a general tendency to recall the pictures in the order in which they were learned, the rule being that any individual picture was more often than not recalled out of its exact order, but in the majority of cases not much out of its order. A minor tendency to recall them in the reverse order is then also detectable.

The order of learning was evidently, in the first place, determined in part by the reading habit. Also, in the recall there was sometimes present a general visual image of the rectangular group of squares in which the pictures were placed. With the presence of such a visual image the reading habit would incline the recall to take the order of the learning. This, because of the thoroughness with which the reading habit is fixed, must have been a more or less constant factor. The order of recall was then, in the second place, fixed, of course, through the working of the principle of contiguity. This was possible in two more or less independent ways. First, in giving a definite sequence of visual images, and secondly, in giving the same sequence in the series of names. Against these factors the influence of others finally broke up the original order of recall. The nature of the results as a whole makes it rather evident that this was due more to a recession of the former

than to an increase in the inherent influence of the antagonizing factors. Of these latter several can be made out with certainty. (1) There was a difference in the inherent spontaneity of the imagery for the different individual pictures. Aside from associative connections, of special interest, of position, or of any other factor that could be detected by introspection, the images of some pictures came up more readily than others and tended to come up before others. (2) An association, apparently from a variety of different causes, might have a special prominence, be recalled first, and with it the pictures it involved. In a good share of instances the subject consciously sought for the associations when the visual image of none of the pictures rose at once directly. Again, in a number of instances the association was related to some personal experience of the subject, giving it a special spontaneity. (3) A general visual image of the positions of the different pictures, which was much aided by the regular arrangement of the squares, in the majority of cases preceded the recall of individual pictures. When for any reason a picture was recalled out of its order, there was a very strong tendency to recall next the one next to it. In this tendency, however, when the original order had once been broken, the one that followed the picture in question in the original order was shown no noticeable preference over others next to it. There seemed to be a tendency to get back to the proper starting place, an expression, undoubtedly, of the tendency to follow the reading habit which was made possible by the presence of this general visual image of positions, but which, in this case, broke the original order still more instead of helping to preserve it. The objective results and the subjects' introspections agree in making this general visual image of the arrangement and positions of the pictures a considerable factor in determining the order of recall. By inference, it would seem that this factor probably also accounts for the slight tendency to recall the group as a whole in the reverse order.

2. *The Associations.* (a) *Their Uses.* Twenty-four cases of associative connections that were made among the pictures while committing them to memory were of such a nature that the history of each could be traced through the four successive recalls. In the present description the figures that are given are based on these cases only.

The function of the associations needs to be considered only in the actual recall of the pictures, and it is assumed that when the subject was conscious of the association *before* the visual image or name of the picture appeared, the association then assisted in the recall. It might, of course, appear after the recall, and then add to the recognitive certainty as to the cor-

rectness of the recall; but it added to recognitive certainty so rarely, occurring only a few times, that it may be left out of account here. The subject did not seem to need this aid to the recognitive process; he was certain that the picture recalled was one of the group without it. In this respect the function of the associations was here essentially different from that in the memory of meaningless forms. The subject's general attitude in regard to their use in the recall was also different. As was the case in learning the group, so in the recall later the associations were much less sought for, were proportionally more numerous, and came in more of their own accord than they ever did with the meaningless forms. This produced in the subjects the general opinion that in many cases the associations were really not needed for recall, that the pictures would have been recalled without them.

The total number of associations that were used in the four successive recalls and whose course could be traced throughout, and the total number of pictures involved in these associations are given in the following table:

	1ST RECALL.	2ND RECALL.	3RD RECALL.	4TH RECALL.		
	Pictures	Pictures	Pictures	Pictures		
Assoc.	Involved.	Assoc.	Involved.	Assoc.	Involved.	
	24	63	15	33	18	32
					16	41

From the previous description of the different kinds of associations, it will be remembered that an association usually involved more than one picture. The conditions of the experiment gave a total possible number of pictures that might have been involved in associative connections at each recall of 96. This gives some measure of the prominence of associative recall. The irregularity of the figures for the second to the fourth recall is evidence of a complexity of the factors involved; they cannot be adequately determined from present results. But in general it is clear that a good share of the associations used in the first recall are not so used in the later ones, approximately a third, on the average, have dropped out in the latter. From other results we might expect the presence of several factors that would influence the use of associations. First, with the repetition of recall, if it is frequent, the direct visual images of the pictures gain relatively in spontaneity and associations drop out. Second, with the lapse of time, if the recall is relatively infrequent, the visual images lose in spontaneity and require former associations for their recall. Third, with the lapse of time the associations are themselves forgotten.<sup>1</sup>

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<sup>1</sup>These three tendencies were found in the memory for meaningless visual forms. See pp. 330-333 of study referred to above.

(b) Their Changes. The general character of the associations in the successive recalls indicates that the two or three pictures that are thus connected, together with the imagery of the associations, constitute a complex of some degree of unitariness. The pictures 'belong together,' seem somewhat separated from the rest in the sense of possessing characteristics that the others do not share, the transition from one element in the complex to the other is very easy, and most of all, there goes with it an affective tone that is characteristic of these other qualities. The complex, however, is a loose and very unstable one. In any given recall, the repetition of such a complex, just as it had appeared in the previous recall, was a very rare occurrence. These changes may be considered under two classes. First, those taking place in the arrangement, relative prominence, and number of elements in the imagery of the associations themselves. Second, disregarding this first class, changes in the way and point at which the associations came in. Considering the latter first, the results show a process of a gradual elimination of the associations. The figures given above show that a good many that were used in the recall on the first occasion were not so used in the later recalls. But there are intermediate stages before they disappear altogether. Allowing for many exceptions, the order is as follows: (1) The association comes in before any of the several associated pictures are recalled. (2) The association appears after the first or second picture is recalled. (3) The association appears after all are recalled. (4) It does not appear at all. Taking the twenty-four cases of associations used in the first recall, and in the first of these four ways, through the second to the fourth recalls gives 72 instances in which these associations might have been used in the last three recalls as they were in the first. But in the last three they appeared in the four ways indicated. Their distribution for these four ways is as follows:

(1)	(2)	(3)	(4)
43%	22%	14%	21%

The other class of changes, the changes in the imagery that constituted the associations themselves, were equally prominent, and the direction of the changes with the lapse of time and the repetition of the recall could also be definitely traced. The predominant tendency was that of a rapid simplification of the imagery, though some other changes, leaving the total imagery equally complex, were also present in a much less degree. Simplification affected all classes of associations, visual and verbal, excepting those cases in which the associative connection consisted merely of combining the names of several

pictures into a phrase or sentence. Other cases of verbal imagery made up of a phrase or short sentence would be very readily reduced to a single word or two. Complex visual imagery would be readily reduced to a single factor of the original. A still further simplification was frequent in the different recalls. In this the only representative of the original association was the 'feeling' that there had been some connection before. The subject would, in these instances, approach the recall of the several pictures that had been associatively connected before with the distinct, very clear consciousness that such association had existed, but would recall the pictures without the appearance of that former visual or verbal imagery that constituted what he called the association. Such an independent feeling of the existence of an association preceding the recall was the form in which the original association persisted in 17% of the cases in which an association was used in the last three recalls.

3. *The Verbal Imagery.* The verbal imagery falls into two classes: (1) The description of the details of the pictures, and (2) Their names.

(1) Description. Verbal description entered at two points in the experiment: (a) In learning the group of pictures the subject had incipiently to some small degree a tendency to describe the visual details. Then (b) at each recall his introspective report necessarily involved detailed description of how he visualized the pictures. These descriptions might thus have been expected to play a part in the later recalls as a means to recall or to reinforcement of cognitive certainty. But as a matter of fact, no description used in learning was ever used or present in later recalls. Verbal descriptions used in previous introspective reports were sometimes recalled; the subject remembered what he had said before, but, considering the results as a whole, this was quite exceptional. The general procedure of the subject was decidedly independent of any memory of what he had said at a previous sitting. A further rather significant fact was that when he did clearly recall a previous description he often put very little reliance on its accuracy as regards the points in the picture described. Present visual imagery, though in itself uncertain in character, seemed more acceptable than the clear recall of description, if the two in any way contradicted each other. On the other hand, when the recall of a description agreed with a somewhat wavering visual image that was recalled first, the verbal memory, with some exceptions, quite readily induced the acceptance of the visual as correct. It reinforced cognitive certainty. The recall of previous description as the sole basis of accepting any point about a picture as correct occurred only a few times.

(2) The Names. The name of the thing in the picture also entered the process of recall in two ways. First, naming followed quite reflexly the appearance of the visual image, the subject being entirely unaware of any intermediate imagery, visual or auditory, of the name. Second, the auditory image of the name entered either before or after the visual image of the picture appeared. In about three-fourths of the cases the subject could tell clearly the order of succession. These give a means of determining the rôle of the name in the recall of the visual image.

It will be remembered that in the trial recalls, during the learning of a group of pictures, the subject's attention went first to the recall of the series of names. This was, without exception, never the case in the recall later. In these the subject's attention was always directed to getting the visual images, either directly or through the associations. At each sitting each picture was recalled twice; first in the general recall of the pictures as wholes, and shortly afterwards in the recall of the details of each individual picture. The following figures give the general percentages of the number of times (a) the visual image appeared first, (b) the verbal appeared first, (c) the visual and verbal appeared simultaneously, so far as the subjects could judge.

	a	b	c
General recall,	77	15	8
Detailed recall,	86	11	4
Average,	82	13	6

This shows at once the very great predominance of the visual imagery over the verbal, and the rather small rôle of the latter in the recall itself. As to its use when it appeared after the visual imagery, it may be stated at once that the name never seemed to affect recognitive certainty at all. Its presence was useless in these cases. The percentages show also that the visual imagery gains in spontaneity with repetition more readily than does the verbal. Since in each case the subject had to name the pictures in his report as well as visualize them, the procedure should not have greatly favored one class of imagery over the other. But it is seen that in the detailed recall the visual is first in 9% more of the cases than in the general. This relation can be followed further by comparing the different recalls with each other, from first to fourth. The following are the percentages:

	1st recall.	2nd recall.	3rd recall.	4th recall.
Visual first,	76	76	89	89
Verbal first,	17	15	11	7
Simultaneous,	7	9	0	4

If, in connection with the relation of visual priority in the general and detailed recalls, it is remembered that in the first recall the general was omitted, it is seen in these last figures that the priority of the visual imagery increases considerably with repetition of the recalls. In the first recall the average for the priority of the visual imagery would be several per cent. less if a general recall had been included. Put into general form, the last two tables mean that with the repetition of the recall the verbal imagery is eliminated from a place where it is not absolutely needed. The visual imagery gains in spontaneity, as compared with the verbal, and is recalled directly. The verbal comes in only after the visual, at a point where it is needed for the purpose of description.

4. *Some Visual Antecedents.* Two kinds of visual imagery that often preceded the recall of the visual image of the picture itself may be given a passing notice. To the subjects their significance never seemed great. But in analyzing the results it appears that the one class at least may have been of considerable use. This is the visual imagery of the rectangular paper with the regular arrangement of squares in which the pictures were placed. The other is the visual image of a dark, quite characterless blotch in the position of the picture, and in some way representing it. The former was of somewhat varying character. Its presence or absence in the first place depended on the ease of recall, the lapse of time, and the absence of associative recall. In the later recalls it was much less present than in the first. Recall through associative connections tended to eliminate it, especially if the recall was easy. In general, it appeared most when there was some interval between the initial effort to recall and the actual recall. It varied in completeness and in the definiteness with which all the squares were simultaneously visualized in a single image. As the extremes, there was, on the one hand, a definite and clear image of the rectangular piece of paper in proper size, color and distance, with a less definite and complete visual image of its 12-15 squares. At the other extreme, this visual antecedent consisted of the visual image of a few squares only, with an indefinite margin, the subject not being conscious of the rectangular form of the piece of paper, of its color, or that it was paper, and it was less definitely fixed as to distance, usually farther off than the original reading distance, and considerably enlarged. It seems safe to attribute to this visual antecedent at least one important function in recall. It gave a means of guiding and fixing the attention. With this visual map before him, the subject could halt his attention and concentrate his efforts on the recall of one individual picture, and could rally his associative aids around this one position until

the picture was recalled. Without such a visual map of positions, or its equivalent in associative connections, he had no starting point, no clue, could not concentrate his efforts, and could do little more than simply wait and let the recall take its own, spontaneous course.

The visual image of a dark blotch in the place of a picture that preceded the recall of the picture itself was often present when the recall did not take place readily. No instance, however, occurred in which it involved any characteristic other than size, position and an indefinite roundness of form. Nothing in it distinguished one picture from another; it contained no clue to recall. Apparently it served no purpose like those of the other aids to recall.

#### D. THE VISUAL IMAGERY IN THE RECALL OF THE DETAILS OF A PICTURE.

We have now to consider the analysis of the recall process after some sort of visual image of the picture as a whole has been obtained, a visual image that has been sufficient perhaps merely to allow the naming of the object and the recognition of the picture recalled as one that belonged to the group memorized. The recall of the details was then a second step, although in individual cases a line could not always be drawn definitely between the two parts of the recall. The details of the simplest of the pictures used were too many to be included in one span of consciousness. The process of their recall was therefore necessarily a succession of imagery of some duration. This was decidedly a visual process. Practically no secondary imagery other than visual ever entered as an aid to getting the visual details after the visual image of the picture as a whole was once reinstated. We have, therefore, in the further analysis of the recall process to consider visual imagery alone. A prominent feature in this was the appearance of much imagery that was wrong. This wrong imagery we shall discuss in the section on "Changes in the Content of the Imagery," after taking up first the general character of the process of the recall of details independently of this wrong imagery.

1. *The General Character of the Process of Recall of Details.*  
(a) Differences in the First and Last Parts Recalled. A few items may be noted first of all in regard to what appeared first in the total imagery and its relation to what followed. The order of the recall of details brought out very clearly the degrees of difference in spontaneity and ease of recall for these details. The easiest was recalled first, and that ease was due not to previous associated imagery, but to the inherent character of the imagery itself. This was shown first of all by the fact that the details that were recalled first were in so many

cases always the same parts of the picture. Other characteristics point to the same general fact. In a good share of instances the first details recalled and what followed were quite distinct in either one of two other ways. First, there might be a considerable interval following the first part before the rest could be recalled at all. Second, the imagery for the first part would be fixed in its character, the following part wavering in both its content and in the degree of certainty that went with it.

(b) The Criteria of Correctness. The recall of details was essentially a process of reconstruction. On the whole the final product that was accepted as correctly representing the original picture was the result of many eliminations and variations of visual details that suggested themselves spontaneously. Usually it was not so much a matter of filling in details somehow or other as it was a matter of deciding which of the details that were readily imaged were the correct ones. The general nature of the process is, therefore, best described further by considering the criteria of correctness and the manner of their use.

Although customary usage applies the term 'recognition' to all such criteria, the present results call for some discrimination. The form and content of consciousness that led the subject to accept a certain detail in the imagery as correct were of several different kinds. (1) Direct recognition may be mentioned as one of these. The term is used now in its most technical sense. In these cases the subject regarded the detail in question as right or wrong directly; he was unable to detect anything, in the character of the imagery itself or in the total process, on which acceptance or rejection might be based. Such recognitive consciousness was not, however, necessarily an immediate result of the imagery. It might appear only after some considerable attention to the imagery, and attempt at decision in some other way. Direct recognition was the most important way of deciding, but it was oftener than not accompanied by other factors as aids. (2) Inherent spontaneity in the imagery frequently led to its acceptance, especially in the absence of other criteria. The influence of this was brought to light clearly in cases in which a detail was visualized in two different ways, neither of which was recognized directly as right or wrong, and either of which might have been correct, so far as other details were concerned. If in such cases there was a distinct difference in the ease, vividness and spontaneity with which the two images appeared, the one having these qualities in the most marked degree was usually accepted, or at least favored as regards correctness. On the other hand, spontaneity and vividness were very readily re-

jected as criteria of correctness in favor of even a slight degree of recognitive consciousness attaching to competing imagery. In numerous instances the subject described certain imagery as very easy to get and vivid, and yet rejected it in favor of other imagery which he faintly recognized as correct, and which at the same time might have been very difficult to get and to hold. (3) The absence of rival imagery increased the tendency to accept whatever did present itself. The effect of rival imagery was shown in instances in which the subject at first recalled a detail in a certain way and accepted it as correct, but a moment later became doubtful of it or even rejected it when another suggested itself, which in itself seemed to have nothing more in its favor than that it was a possibility. In general, the suggestion of more than one possible way of recalling a picture created doubt where otherwise there might have been considerable certainty. Another tendency shown was that of rival imagery to drop out with the lapse of time and the repetition of recall. Where such was the case it was the rule of the subject to accept as correct what he did recall, though he had previously doubted its correctness in the presence of rival imagery. (4) Something in the nature of a process of inference was a very prominent method of deciding whether the imagery of a certain detail was correct or not, and was also a factor in producing that imagery in the first place.<sup>1</sup> This was so closely interwoven with the other factors that it was throughout difficult for the subject to detect its presence, or to say whether he believed a thing was so because of a direct recognition of its correctness, etc., or because he inferred it to be so on account of other things that he did so recognize or know. A detail might, of course, be inferred to be right for many different reasons. The results hardly allow any classification of the grounds for such inferences. Two sources, however, can be made out. First, the subject would recall certain details and be certain of their correctness. With this accepted, the nature of other details often followed necessarily. Secondly, in some cases he inferred details in the picture from what he knew of the thing represented by it, without any connection with details actually recalled. It is very evident, when other results in this connection are taken into account, that in very many instances some such process as this guided the recall and rejection or acceptance of imagery when the subject was not in the slightest degree aware that this was his method. Clear cases in which the subject reported that he

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<sup>1</sup> The term inference, for want of another, is used here in a wide and loose sense, and is not to be defined in the formal way of the logician.

was inferring rather than remembering were very few, less than fifty in all the results. And in many of these he discovered this fact only after special questioning. On the other hand, memory illusions were numerous, but the details in these illusions were almost without exception wholly consistent with themselves. Though the subject constructed and accepted as correct a total image that was quite different from the picture, the construction was consistent with itself. It is clear, I think, that if that construction had been guided alone by direct, but in this case false, recognition and the other criteria of correctness already mentioned, it would frequently have resulted in a group of details for a picture that would have been quite inconsistent with each other.

The criteria of correctness changed somewhat with the lapse of time. In the first place, the general spontaneity of the imagery decreased. After the second or third recall it was evident to all the subjects that the pictures were recalled with much less ease, clearness, and detail. Second, the intensity of direct cognitive consciousness decreased. This took place, however, apparently from two quite different causes. For a few of the details that had always been very readily recalled and with perfect certainty as to correctness, the imagery came to be accepted later in a rather matter of course way, an attitude which, in the perception of familiar objects, is described as 'cognitive' rather than 'recognitive' consciousness. On the other hand, more frequently the intensity of cognitive consciousness decreased because of a loss of memory, the subject being less rather than more certain of the correctness of the details in question, so far as direct recognition was his means of judging. Thirdly, in some cases rival imagery dropped out. Details that were at first imaged in more than one way, the subject being uncertain as to which way was correct, were later imaged in one of the former ways only, the old alternative not occurring to the subject at all. In other cases rival imagery appeared in the later recalls that was not present at first. This seemed in general related to a decrease in certainty, from whatever cause, for some details. Certainty at first for a given detail barred out rival imagery. Later uncertainty gave the possibility of that detail being imaged in other ways and with an equal claim to correctness.

2. *Changes in the Content of the Imagery.* We may consider next the general character of the changes that appeared in the content of the imagery with the lapse of time. By changes in the content is meant now wrong imagery in the later recalls for details that were in the first recalls imaged correctly. These changes fall conveniently into two classes. (a) Imagery that presented itself more or less spontaneously, but which the sub-

ject regarded as wrong. I shall call this conscious change. (b) Imagery that was wrong, but which the subject regarded as correct, illusions of memory. For the purpose of description these may be kept separate. But we shall see later that they are more closely related than their separate description might indicate.

(a) Conscious Changes. Following distinctions made in describing the criteria of correctness, the conscious changes in the imagery were of two kinds. First, the changes that were directly recognized as wrong. Second, the changes that were inferred to be wrong because of other known facts. These were the two methods that the subject was conscious of using in judging imagery. By far the greater part of the cases belonged to the former. As stated before, the recall was a reconstruction process consisting essentially of eliminating wrong imagery and deciding on what was wrong and what was correct. The tendency for imagery to come up that was at once recognized as wrong increased decidedly with the lapse of time. In some individual cases it bore the further characteristic of a high degree of vividness and persistence. Although at once regarded as wrong, the subject had difficulty in dispelling it. In the case of one subject such imagery was so prominent as to attract his attention and occasionally call forth generalizations on his own part. Thus in the third recall of one picture he said, "I find it very difficult to get a visual image that can be accepted. Various kinds of details come up that are at once recognized as wrong, but which, in the inability to get correct ones, are persistent." In the fourth recall of another picture he notes: "A number of visual details come up that are at once recognized as wrong. The visual imagery of these details comes up readily and clearly, while at the same time different details that are recognized as right are vague, hard to get and to hold." Such descriptions never occurred in the first recalls, and only a few times in the second, while they are frequent in the third and fourth. The generalization of this subject is verified by many concrete descriptions that state just what the imagery was and the whole process that ended in the acceptance of certain details as the correct ones. There was, however, apparently considerable individual difference among the five subjects on this point.<sup>1</sup>

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<sup>1</sup> This individual difference appears in the introspective notes, when they are taken literally. I am not certain, however, but that the subjects were more alike in this respect than their own notes would indicate. Occasional special questioning showed that their *habits of introspective observation* were different, and in such a way as to account for a difference in their reports where the process of recall might have been really quite the same. In all there was a strong

What was said above of the grounds for inferring imagery to be correct holds true in quite the same way of the grounds for inferring imagery to be wrong. Imagery was inferred to be wrong from various reasons. To the two sources of inferences in the former case must be added now a special class, inferences based on the memory of a generalization made about the pictures. There were no colors in any of the pictures, and, of course, no motions. The subject could not forget these general facts. In the later recalls the things in the pictures were very frequently visualized in colors, and some of them as moving. These characteristics of the imagery were, of course, readily detected to be wrong. Every one of the pictures was visualized in colors at one time or another in the later recalls by one subject or another. These colors were always the natural colors of the objects represented. A further peculiarity was then the fact that in some cases only a part of the object was visualized in its natural color, while the rest was imaged in the black and white of the picture. In the picture of a child, for example, one subject imaged its hair as brown, with no further color. Another subject imaged a ribbon in pink, with no further color in the dress. In a picture of a human eye the iris was imaged as blue, with the lids and brow in the black and white of the picture. The ends of the handle of a jackknife were imaged in brass color, the rest in black and white. The drumsticks with a drum were visualized in wood color and black paint, the drum itself in black and white, etc.

The objects were also imaged in motion, but more rarely than in colors, a fact evidently dependent on the nature of the object, for not all the objects pictured were mobile. There is some slight evidence also that those objects in which motion might have been imaged were not imaged in that way so readily as in colors. I quote a few of the more striking cases, which reflect the general character of this class of conscious changes. Third recall of a picture of a locomotive: "With

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tendency to attend only to the final product of the process of recall, the imagery accepted as correct, and a corresponding disregard of the process by which this had been reached. Quite frequently the steps in the process were forgotten by the time the end product had been described. This fact has an interest independent of its present connection; for the strong tendency to direct the attention in this way seems to be an illustration of the fact that in everyday life we rarely are interested in *how* we attain an end mentally, but only in what we accomplish. In memory, especially, we have no practical interest in *how* we remember, but only in *what* we remember. The point of present importance in this is the fact that the different subjects did not succeed equally in directing attention to the process, the antecedent imagery, as well as to the product.

further attention to the imagery the locomotive begins to move, especially the drive wheels and the piston rod. I see the puffs of smoke and steam. It is almost impossible to visualize it as standing still." Third recall of a picture of a top: "The visual image of a running top is persistent. With continued attention, it begins to wobble and sway, like a running top that is stopping." Fourth recall of a picture of a dog: "There is a little difficulty in visualizing the position correctly. The dog in the image keeps turning its head around to look at me." Fourth recall of a picture of a cow: "With further attention its head turns towards me. I see it move, with the added feeling that I am visualizing a real, live cow. This sort of imagery persists, and the visual image of the correct position comes out only in short flashes." The persistence of the motion and the relative inability to image the object as stationery was characteristic of the imagery of one subject only, and with him it was not true, of course, of all the pictures; but only one of the five subjects never reported motion in any of his imagery. Individual differences were greater in this than they were for visualizing the things in their natural colors.

It was stated that these conscious changes in the imagery increased with the lapse of time. Most belong to the third and fourth recalls. No imagery of motion belongs to the first recall. Taking the more prominent cases, 99 in all, of visualizing color or motion, gives the following distribution for the different recalls, first to fourth:

1st Recall.	2nd Recall.	3rd Recall.	4th Recall.
10%	19%	29%	42%

The conscious changes in the imagery directly recognized as wrong (the class mentioned earlier), because of their nature and number were too incompletely recorded in the notes to justify giving figures. But the record as it is, and the occasional generalization on the part of one of the subjects, indicate that their course was much the same as was that for color and motion.

Without discussing the conscious changes at this point, most of what is included in their description may be brought together under one generalization. The imagery tends, with the lapse of time, toward the imagery of the object represented by the picture, and with this change takes on characteristics that belong to the object, but which are not represented in the picture. It will be helpful to keep in mind this generalization in considering the next class of changes in the content of the imagery, the memory illusions.

(b) Memory Illusions. If the term were taken in its strictest sense it might be demanded that only those cases should be

called memory illusions which were due to false cognitive consciousness. I shall, however, not so limit the term, but shall regard all wrong imagery that is accepted as correct as memory illusion, no matter what the criterion for acceptance has been.

The general frequency of illusions could not be determined definitely in the present study because of the fact that time never permitted the subject to give a really complete description of the details of his imagery. But taking the results as they stand, they show a large percentage of illusion. Its amount varied much with the different subjects, and more still with the different pictures. For some pictures some subjects never made any misstatements. For other pictures some subjects, in individual cases, described three-fourths of the details wrongly.<sup>1</sup> Taking the more marked instances of memory illusions, 280 cases in all, we find the following individual differences among the five subjects:

Subjects,	1	2	3	4	5
Per cent. of illusion,	17%	25%	9%	29%	32%

The conditions of the experiment were the same for the first three subjects; for the fourth and fifth the number of pictures in a group and the time allowed for learning a group were less, and the intervals between successive recalls were greater. The individual differences were probably due, in part, to this. Dividing the subjects into two groups accordingly, and figuring the percentages separately for each group gives:

Subjects,	1	2	3	4	5
Per cent. of illusion,	33%	49%	18%	42%	58%

The first subject described less of the details in the pictures than any of the others. The third gave his introspections in considerably more detail than any of the others, though not describing more of the details in the pictures. This led to greater discrimination in the characteristics of the imagery, etc., and made him more guarded in his statements as to what he really accepted as correct. Nothing further was found that might account for the individual differences in the amount of memory illusion.

There was some data also on the relation of the amount of

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<sup>1</sup> Several recent memory studies give results on the frequency of memory illusion. They show very great variations in the amount of illusion as dependent on the different kinds of material to be remembered, and other conditions. In the general average it amounts to about 20%. I have summarized most of these results in another place. See "Recent Studies of Normal Illusions of Memory," *Am. Jour. Psy.*, 1905, pp. 389 ff.

memory illusion to the lapse of time and the repetition of recall. At least the first recall compared with any of the later ones gives considerably less illusion. Taking the same 280 cases used above gives the following distribution for the different recalls:

1st Recall.	2nd Recall.	3rd Recall.	4th Recall.
15%	30%	25%	30%

The results do not permit a definite statement as to why the amount of illusion did not increase regularly with the lapse of time, but several factors should be taken into account. First, a number of the illusions that were present in the first recall remained fixed throughout. Secondly, in the later recalls many of the details in the pictures were forgotten altogether, thus eliminating the possibility of making misstatements about them. Thirdly, the efficiency of the different criteria of correctness did not decline at the same rate as did the ability to recall details at all. Thus the amount of illusion in any given recall might be more or less than it had been previously according as these various factors were related to each other at the given time.<sup>1</sup>

An attempt to classify the memory illusions for the sake of describing their general character from the standpoint of the details in the pictures that were changed soon revealed the fact that they were literally of all sorts. The range of their variety seemed limited only by the possibilities of the things represented by the pictures. Any change in the object represented, which would not make it different from what the object ever actually is, might be introduced. Different groupings bring out different aspects of the tendency to illusion. Thus (a) with reference to the pictures described, details not in the picture might be added, or the presence of some that were there might be denied, or the number of parts of one class in a picture changed. The relative position of different parts were changed, the form of a part described differently from what it was, or the position of the picture as a whole changed so as to give a different view of the object represented. Taking another standpoint of classification, (b) with reference to their permanency, some remained unchanged, as already stated with regard to some of those that appeared in the first recall. In a good many cases the subject wavered back and forth between two statements, one or both of which might, in a pre-

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<sup>1</sup> Some figures from other memory studies show something of the relation of the amount of illusion to the lapse of time. These all agree in showing some increase with successive recalls. See summary of studies of memory illusion referred to above, *Am. Jour. Psy.*, 1905, p. 393.

vious recall, have been regarded as uncertain. A smaller number changed to a third and even fourth characteristic, without reverting to a former one. Classifying them (c) with reference to the way in which they entered, three sub-classes may be noted. In the majority of cases the details in question were simply visualized wrongly but 'recognized' as correct. No immediate clue to their origin was given. Many belonged to a class often noticed by casual observers. Details would at first be described wrongly but with uncertainty, or regarded as mere irrelevant imagery minus all memory sanction. Later the same description would be given, but without the previous uncertainty; it would be regarded as correct. A few clear cases occurred in which the subject simply reasoned wrongly in reconstructing his total image. He inferred that a detail must be so, on the basis of what he did remember of the picture or knew of the object, overlooking some other possibility.

Figures may be given for the classification from the first of these three standpoints (a) above. For they will reinforce a generalization of importance already suggested with reference to their causes. Taking the 280 cases used before, three classes may be made that cover all but 17% of the total number. These are (1) relation of parts changed, (2) the form of a part changed, (3) the position of the picture as a whole changed, giving a different view of the object represented, (4) the miscellaneous group containing the remainder of the cases, details added, details that were present denied, and the number of a class of things in a picture changed. The percentages of cases belonging to these classes are then as follows:

1	2	3	4
16%	34%	33%	17%

In considering these figures it must be noted that ten of the thirty pictures used were of such a nature as could not be affected by the first class of illusions, their being no parts to the objects represented whose relations could be changed and still leave the objects as they ever actually are. On the other hand, it should be remembered that there was much less occasion for the third class to be numerous than there was for the first or second; for there were necessarily much fewer whole pictures than there were parts in all the pictures. This brings out the fact that there was a specially strong tendency to illusion of the third sort; we may safely say, more than twice as great as for any other of these classes, although only 33% of the cases belong to it.

(c) Causes of Changes. A determination of the special causes of the changes in the content of the imagery with the lapse of time is in the present study for the most part a matter

of interpretation. Bringing together a number of salient features that the general analysis has revealed will throw some light on this question. In the first place, it seems quite evident that the conscious changes and the memory illusions are both due to one and the same general cause. This is expressed in the generalization already made that the imagery of the picture tends to the imagery of the object represented by the picture. Whether or not the change will be a memory illusion or the subject be conscious that it is a change depends on special and largely quite incidental conditions. The validity of this generalization follows from the fact that both the conscious changes and the memory illusions were of almost unlimited variety, but were never inconsistent with the possibilities of the object. As stated of the illusions, any change might occur which was not different from what the object ever actually is. It is reinforced by the special prominence of the imagery of color and motion, and by the predominance of memory illusions that involved a changed position for the object, the object turned around somewhat as a whole. The last could occur for the imagery of the object without changing the object, but it could not occur for the imagery of the picture without changing the picture.

Some reasons may be given why there should be this tendency for the imagery to change to that of the object. The first three are facts of observation in the present study. In the first place the general spontaneity of the correct imagery, the imagery of the picture as seen, declined with the lapse of time. The more this was true the more was given the possibility for imagery of the object to present itself. Secondly, spontaneity was to some degree a criterion for accepting imagery as correct and lack of it for rejecting it as wrong, giving a further cause for the right imagery to drop out and the wrong to remain. Thirdly, the intensity of direct cognitive consciousness decreased, and thus permitted the elimination of the right imagery in favor of other imagery that was wrong. These are negative causes, favoring the decline of the imagery of the picture as seen. On the other hand, it may be said that the objects represented rather than the particular pictures of the objects were more matters of everyday experience of the subject. The two were undoubtedly somewhat different in every case. Thus the imagery of the object was the more usual, customary, habitual, and the mind in making the substitution simply followed the law of habit. This is a generalization that has already been made from other memory studies, and the tendency in question may be accepted as a factor here. But there are additional reasons why this should be so for the memory for pictures. Pictures as such have not the interest

and emotional coloring that belong to the objects. Such emotional coloring, when it takes possession of consciousness, brings with it the visual imagery with which it is connected. Again, in so far as meaning and interpretation is read into the picture at all, so far, of course, the picture ceases to be what it is and becomes the object. The picture just to this extent creates the tendency to substitute the imagery of the object in its natural setting.

A few things further may be noted in summary in regard to what determines whether a change that has taken place in the imagery shall be a conscious change or memory illusion. We have found two general checks to illusion when wrong imagery appeared. First, cognitive consciousness, although declining in efficiency, is more persistent than the original spontaneity of the correct imagery. Wrong imagery may increase in amount and persistency, but the larger share of it is at once recognized as wrong. This is in accord with the fact found in other memory studies which shows that more things can be recognized as belonging to a previous experience when given a second time together with others than can be directly recalled without such second presentation. Secondly, inference from other remembered or known facts prevents illusion. Clearly this is what prevented imagery of color and of motion from becoming illusion. If some of the pictures had been colored, or if they had been objects, some of them in motion, mistakes would undoubtedly have occurred by attributing color or motion to individual cases where none had been present. As it was, the subject could hardly forget that no color or motion belonged to any of the pictures. In the case of imaging the object represented in the position represented in the picture there was no such check. The object could be imaged from any side or turned in any way. No generalization that might have been remembered applied, and we have consequently many illusions belonging to this class.

Finally, the varying relations of all these factors that produce changes in the content of the imagery account for the fact that the course of the increase in memory illusion through the four recalls was not the same as was the course of increase in the conscious changes.

#### E. SUMMARY.

In the experiments above described the subjects all learned the pictures in regular order from left to right and from the top downwards. They also all alternated looking at the pictures with trial recalls, giving about half the time to the latter. Their stated purpose in this was to determine what needed special attention and what could already be recalled. While

looking at the pictures the attention went predominantly to noting the details visually. In the trial recalls, however, the effort was predominantly to recall the series of names of the objects represented. Calling the visual method the direct method of learning, certain aids to the visual process were used. These were the names of the things in the pictures, verbal description of their details, and associations with individual pictures and between different pictures. The use of verbal description for details was very rare. The use of associations was abundant. They were easily obtained, and were of a large variety.

Factors determining the order of recall of the pictures gave some evidence as to the factors present and their relative efficiency in the recall of the pictures as wholes. The order of learning was followed in the first recall, but this order broke up gradually with the lapse of time. Factors that tended to break up the original order were: (1) Differences in the inherent spontaneity of the imagery for the different pictures; (2) Special prominence of the imagery of associations; (3) A general visual image of the regular arrangement of squares in which the pictures were placed.

Associations were abundantly used in getting the visual image of a picture as a whole in the first recall. Approximately a third of them were *not* so used in the later recalls. When the associations appeared after the visual images of the pictures, they practically never reinforced recognitive certainty; they were not needed for this purpose. Changes occurred in the nature of the associations and the manner of their use with the lapse of time. The imagery of the associations together with that of the associated pictures constituted a loose complex. Time produced a gradual elimination of the associations from this complex, which, with many exceptions, ran roughly as follows: (1) The association appeared before any of the associated pictures were recalled. (2) It appeared after the first or second was recalled. (3) It appeared after all were recalled. (4) It did not appear at all. A second class of changes consisted in a rapid simplification of the imagery of the associations. In this a final stage before complete elimination was, in 17% of the cases, the mere 'feeling' that there had been some association before.

Verbal imagery used in recall was that of the description of details, and naming. Verbal description used in learning was never used later in recall. Verbal description used in an introspective recall was sometimes remembered in a following one, but the subject made little use of such verbal memory, and put little reliance on its accuracy. The naming of the thing in the picture followed its visual image reflexly, or an auditory

image of the name preceded or followed the visual image. When it followed the visual it never influenced recognitive certainty. In 13% of the cases it preceded the visual image and was thus used in recall. In 82% the visual preceded, and in 6% the two seemed simultaneous. The priority of the visual image increased about 10% during the later recalls, as compared with the first.

Two kinds of visual imagery, aside from visual imagery involved in associations, often preceded the visual image of the picture. These were a visual image of the rectangular piece of paper with its regular arrangement of squares, and the image of a dark, otherwise quite characterless blotch in the place of a picture in a square. The former varied considerably in its general character. Its main function seems to have been that of guiding and fixing attention in the effort to recall individual pictures. The latter did not vary in character for different pictures; it served no function that could be determined.

The recall of details of a given picture was necessarily a process of some duration. Some differences in the character and manner of recall were found for what appeared first and last in that process. The part recalled first consisted of the easiest details, which were apt to be the same in successive recalls, with the nature of the content of their imagery fixed, and the subject certain as to its correctness. For the last part the details entering varied more, the nature of the imagery was not so fixed, and the subject was less certain. The two were often separated by a considerable time interval.

The recall of details was further a process of *reconstruction*, a reconstruction by means of eliminating wrong imagery more than one of producing imagery that was right in the first place. The criteria by means of which imagery was judged right or wrong or because of which it was accepted or rejected thus become the essential part in the actual recall process. Several such criteria were made out. (1) Direct recognition, using the term in its limited, technical sense. (2) Special inherent spontaneity of the imagery frequently led to its acceptance, especially in the absence of other criteria. But this characteristic was very readily discarded as evidence of correctness in the presence of even a very slight degree of recognitive consciousness attaching to other imagery. (3) The absence of rival imagery increased the tendency to accept whatever did present itself. (4) Inference, using the term in a very loose way, was a prominent method of deciding on the correctness of imagery. Without special and minute attention, the subject found it generally very difficult to discover that this had been his method in cases where actually it was so. Inferences were made on the basis of details already definitely recalled,

and on the basis of what the subject knew about the things represented in the pictures. Indirect evidence from the memory illusions also indicates that this played a large rôle in recall. These several criteria changed somewhat with the lapse of time. First, the general spontaneity of the correct visual imagery decreased. Second, the intensity of cognitive consciousness decreased. Third, rival imagery dropped out in some cases; in other instances it appeared where it had not been before.

Changes in the content of the imagery that occurred may be described as: (1) Conscious changes, wrong imagery which the subject knew to be wrong, and (2) Memory illusion. In the majority of cases of conscious changes the subject knew the imagery to be wrong by direct recognition. Such imagery increased very much with the lapse of time, and had in some cases the further characteristic of a high degree of persistence. In a second class of conscious changes the imagery was inferred to be wrong from other data recalled or known. Among these the tendency to visualize color and motion in the pictures is of special significance. These were always the natural colors and motions of the objects represented. This tendency to color and motion also increased quite regularly from 10% of the total number in the first recall to 42% in the fourth. The memory illusions showed great variation in their general frequency for the different subjects and for the different pictures. Fifteen per cent. of the total number occurred in the first recall, with 30%, 25%, and 30% for the second, third and fourth recalls respectively. There was some additional evidence that a changing relationship of several factors, militating both for and against the illusions, determined their relative frequency at any given time. From the standpoint of the details in the pictures that were changed the illusions were limited in variety apparently only by the possibilities of the objects represented, any change being likely to occur that did not make the object different from what it ever actually is. Making an arbitrary classification from this standpoint showed that there was a specially strong tendency to illusion of the position of the object represented, *i. e.*, a changed view of the object.

One and the same general cause produced both conscious changes and memory illusions. This was *the tendency of the imagery of the picture to change to the imagery of the object represented*. Special reasons why this should occur are: (1) The spontaneity of correct imagery declined with the lapse of time. (2) Spontaneity, or lack of it, was to some degree a criterion for accepting imagery as correct or for rejecting it as wrong. (3) The intensity of direct cognitive consciousness decreased. (4) The object rather than its picture was more a matter of

everyday experience, and its imagery readier, and more habitual. (5) More interest and emotional coloring belongs to objects than to their pictures. (6) To the extent that the picture represents and suggests the object the imagery of the object is already given.